Impact of Sustainable Energy Projects on Local Roads in Indiana

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- Technical Advisory Committee members
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Background

- Renewable/sustainable energy sources are being developed at a record pace
- The number of ethanol plants and wind farms estimated to triple by 2022
- Most local road networks are inadequate for the loads
- Local officials must deal with energy development

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Objective

- Develop tools for local agencies
  - Quantify effects of proposed projects
  - Determine appropriate pavement sections
  - Quantify costs
  - Easy to use

Sustainable Energy in Indiana

- Ethanol (938 million gallons)
  - Corn
- Bio-diesel (118 million gallons)
  - Soybeans
- Bio-mass (20-30 megawatts/plant)
  - Stover, wood waste
- Wind (1000 megawatts)

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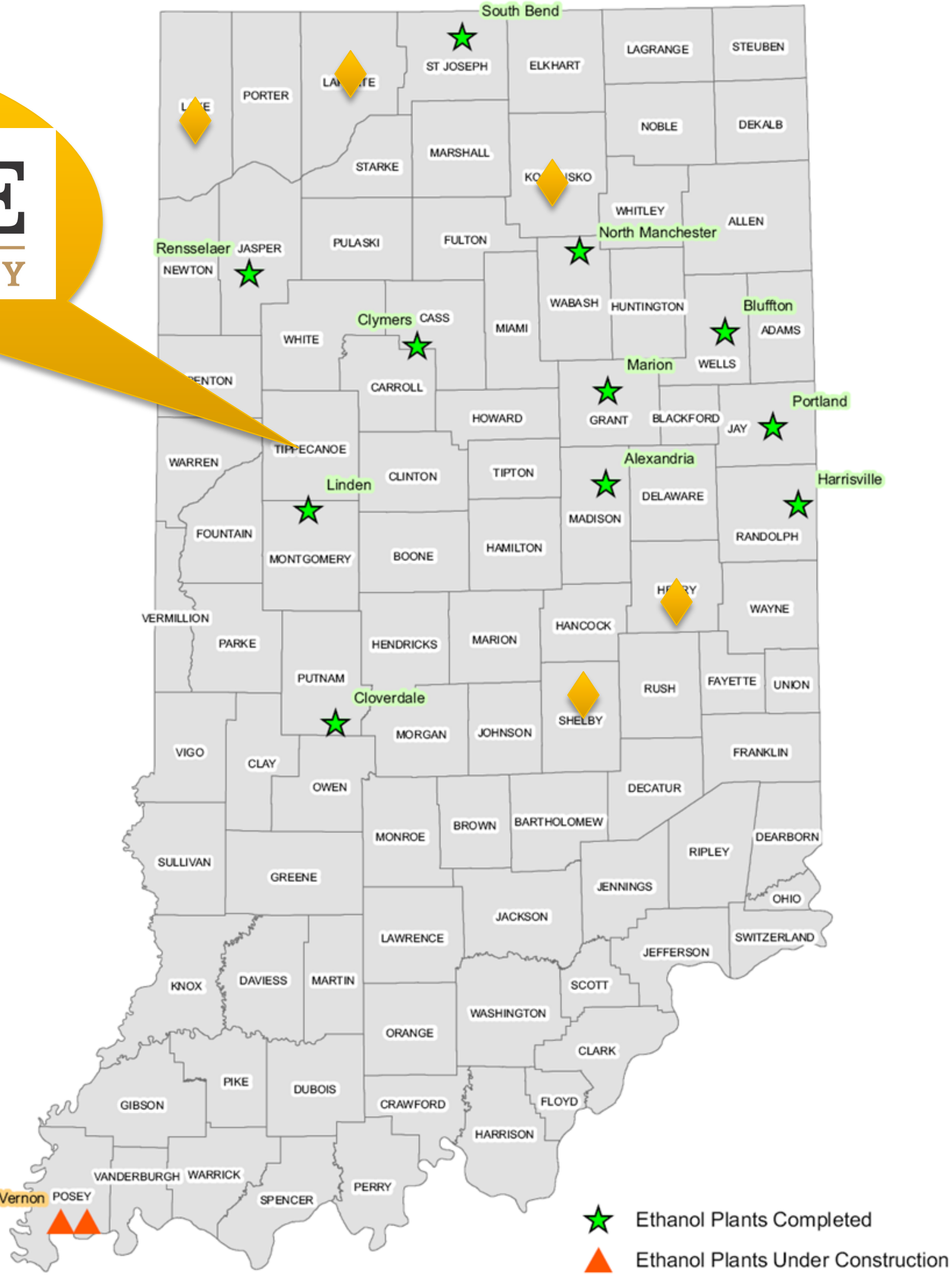

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Project Plan

- Devise methodology
- Identify inputs and assumptions
- Develop tools
- Validate
  - Data collection
  - Compare results

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Methodology

- Spreadsheet
  1. Ethanol and biomass worksheet
  2. Wind farm worksheet

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Methodology

- Ethanol, biomass pavement designs, 1993 AASHTO design guide
- Load repetitions are important

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Design Methodology

- Wind turbines have large, heavy components
- Asphalt Institute MS-23
  - Thickness Design: Asphalt Pavements For Heavy Wheel Loads
- Emphasizes loads applied rather than repetitions

Inputs and Assumptions

- In order to simplify the design process, assumptions were made
- All assumptions can be changed by the user

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Inputs

- Primary inputs (project specific)
  - Plant capacity
  - Design period
  - Subgrade CBR

Inputs

- Secondary inputs (uniform for projects)
  - Yearly growth factor
  - Biofuel products and raw materials
    - Material trucked into plant
    - Fuel trucked out of plant
    - By-products trucked out
  - Biomass fuel type

Inputs

- Secondary inputs (uniform for projects)
  - Reliability
  - Terminal Serviceability Index (P_t)
  - Overall standard deviation

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Input

Input Data	Value
Plant capacity, MGY	100
Design Period, years	20
Yearly Growth Factor, %	0
Corn Trucked In, %	100
Ethanol Trucked Out, %	10
DDGS Trucked Out,%	100
Output, W18	1,804,430

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Input

Input Data	Value
California Bearing Ratio, %	3
Reliability, %	75
Terminal Serviceability	2.0
Overall Standard Deviation	0.45
Output, SN	3.99

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Assumptions

- Typical truck capacity is 3200 cubic feet
- 0.354 bushels of corn/gallon of ethanol
- 1 million gallons of ethanol has byproduct of 3200 tons of DDGS
- 4th power law load equivalency factors
- Biomass facility weight of fuel
  - 15,226 BTU/kW-h
  - 4250 BTU/lbs of fuel

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Validation-Data Collection

- 16 counties with ethanol and biomass plants were contacted
- 12 responded and were interviewed
- Only 4 had performed any type of local road upgrades

Validation

- 3 of 12 counties were able to provide pavement layer thickness after the pavements were upgraded for biomass and ethanol plants

Validation

County	As-built SN	10-yr Design SN	20-yr Design SN
Jay	1.8	3.1	3.4
Posey	2.2	3.2	3.6
Wabash	3.8	3.4	3.8

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Cost Calculation

- The costs for the thickness combinations are produced using user-defined costs
- The user has the option of specifying his/her own layer combinations

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Cost Estimates

County	Alt 1	Alt 2	Alt 3	Alt 4
Jay	$246,744	$247,468	$262,624	$259,417
Posey	$249,060	$254,417	$282,769	$266,306
Wabash	$260,082	$263,182	$302,414	$276,140

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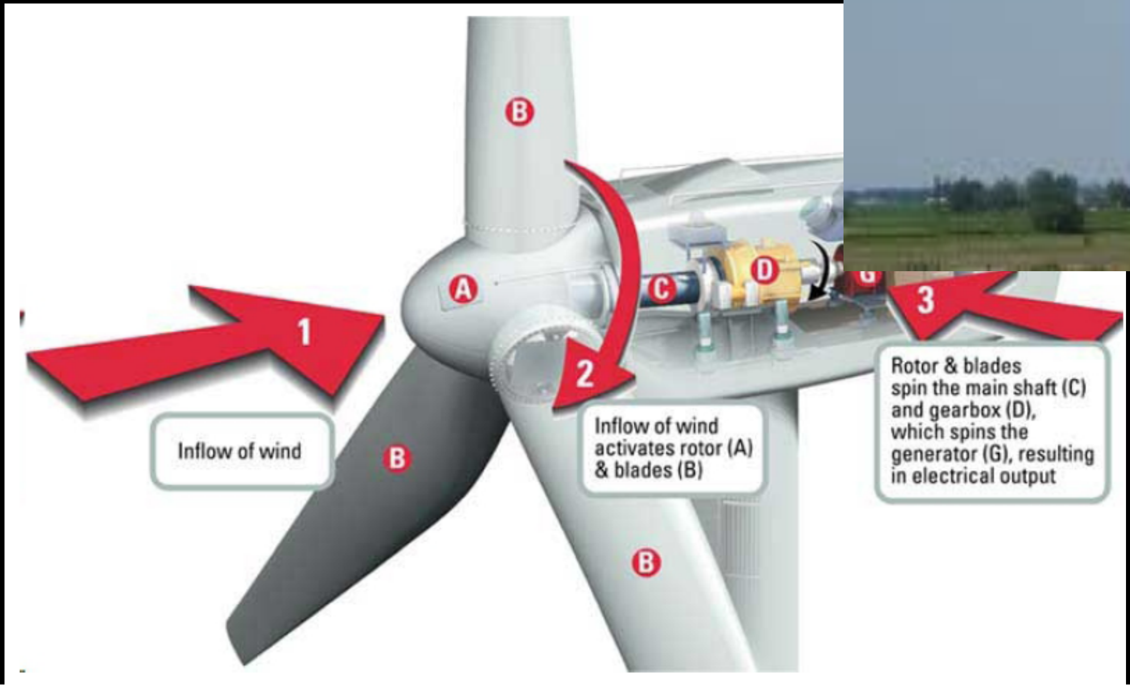
Wind Energy



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Truck loads

- Truck traffic limited to construction traffic
  - Construction materials
  - Construction equipment (cranes)
  - Turbine components (nacelle, rotor, blades, and tower sections).
- Construction materials are the heaviest loads per truck axle, not wind turbine components

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Construction Materials

Material	Trucks Required
Aggregate	10
Concrete	20-40
Steel	1

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Inputs and Assumptions

- Primary Inputs
  - Number of turbines
  - CBR
- Secondary Inputs
  - Tire contact area (100 in^2)

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Validation-Data collection

- Interview county personnel from White and Benton counties
- In both cases, wind farm developer signed a road use agreement with the county
- Developer is responsible for road condition

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Validation

- In 2008, Horizon Wind Energy began project in White County
- The engineering consulting firm developed a pavement design

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Validation

Input	Consultant Design	Worksheet
No. of Turbines	127	127
CBR, %	3	3
SN	1.3	1.9

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Validation

- Worksheet provides a higher SN
- Could be due to the choice of design procedure
- Low volume road design is also applicable because the number of ESAL is small
- Heavy wheel design more closely matches the given traffic scenario

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Cost Estimates

County	Alt 1	Alt 2
White	$196,448	$165,612

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Conclusions

- Tools to aid local agencies were developed
- Spreadsheet based
  - Quantify effects of proposed projects
  - Determine appropriate pavement sections
  - Quantify costs
  - Easy to use

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Recommendations

- Include biodiesel plants
- Further validate the worksheet
- Comparing the design output with implemented designs after time interval

Questions?